



EUCOM
United States European Command



Humanitarian Mine Finder Experiment for Humanitarian Demining (HD)



June 2009

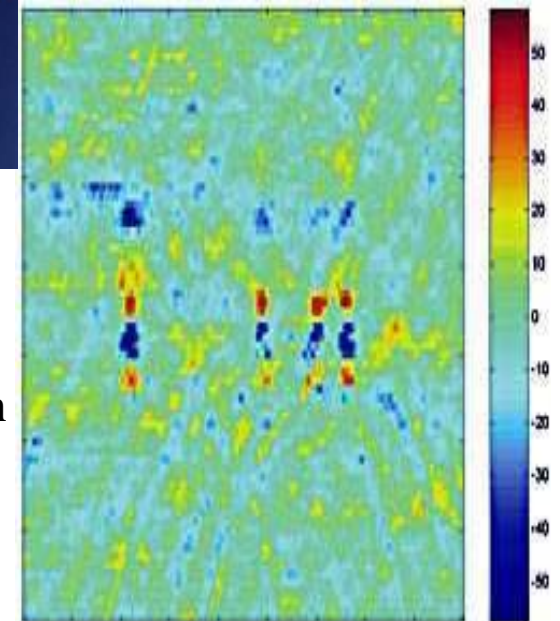
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Naval Air Warfare Center Aircraft Division

Advanced Concepts

In support of

EUCOM J8



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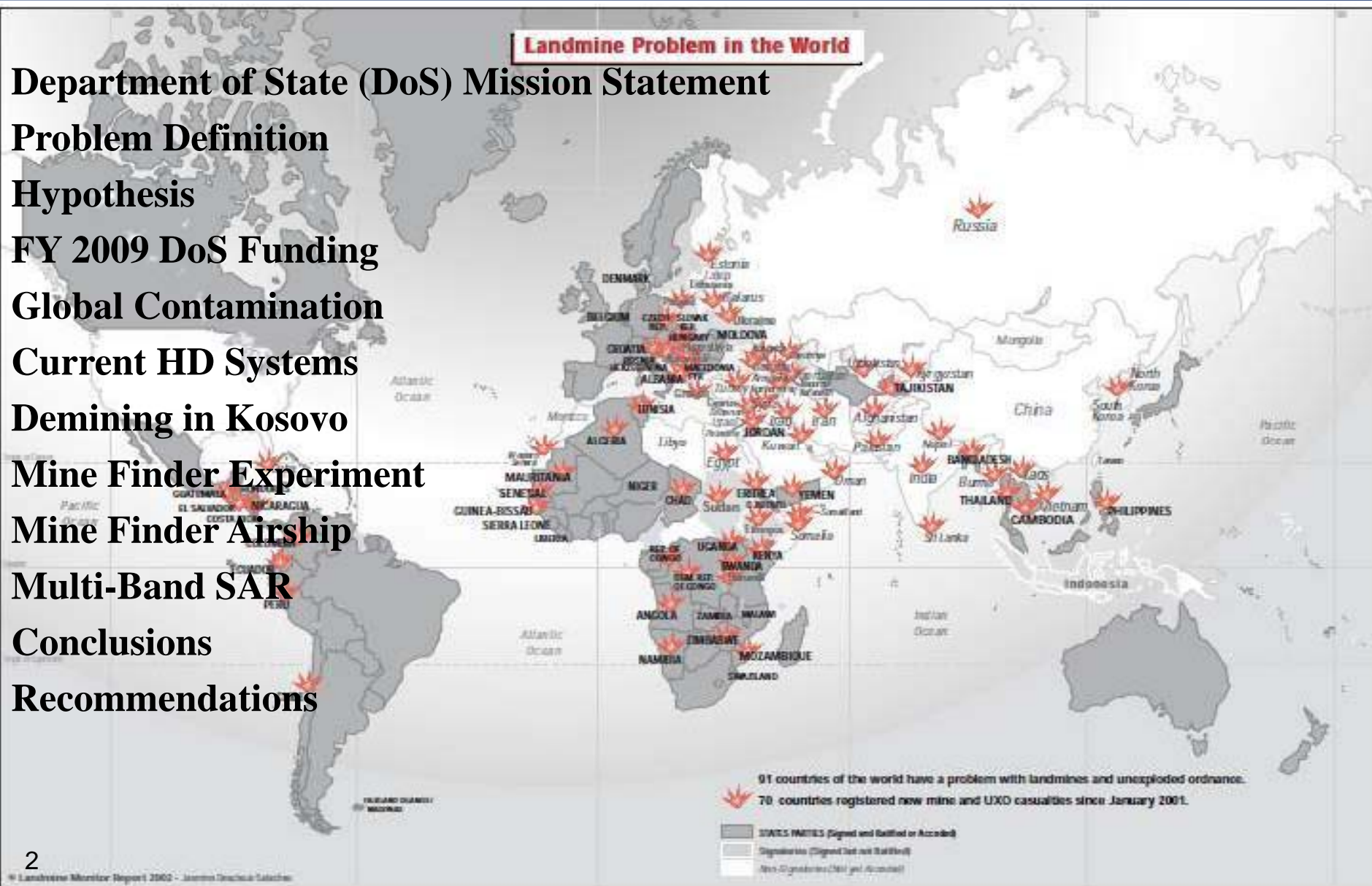
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Landmine Problem in the World



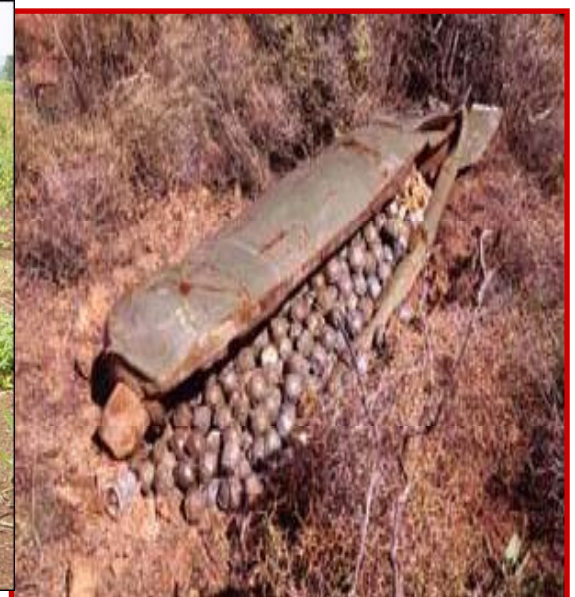


DoS HD Mission Statement



"I think we do agree on one central goal, and that is the need to end the threat that landmines pose to civilians. The best way to do that is to proceed full speed ahead with the job of pulling mines from the soil like the noxious weeds that they are. I am proud that the United States is far and away the world leader in mine removal programs."

Secretary of State Madeleine K. Albright, 8 April 1999





Problem Definition

Landmines:



- The hard part is **DETECTING** the mines and UXO
- Current methods of detection and removal are **Slow and Dangerous**

- Current funding (DoS and DoD) levels are inadequate to seriously address the problem

- Mines and Unexploded Ordnance (UXO) are a major problem around the world.





Hypothesis



- An Airship equipped with multiple bands of synthetic aperture radar that operate in a full polar metric mode, when operated at low altitudes (below 1000ft agl) and flying at slow speeds (20-40 knts) will be able to detect mines and UXO in a variety of conditions (terrain). This method of locating mines and UXO will be more efficient (faster) and safer (man out of the mine field) than current methods. Mine Finder can also provide opportunities to gain access and influence in countries of interest





FY2009 DoS Funding

Nonproliferation, Anti-terrorism, Demining, and related Programs



“As of March, the GAO said average **monthly** costs to fund military operations in Iraq and Afghanistan has reached roughly **\$12.3 billion**”

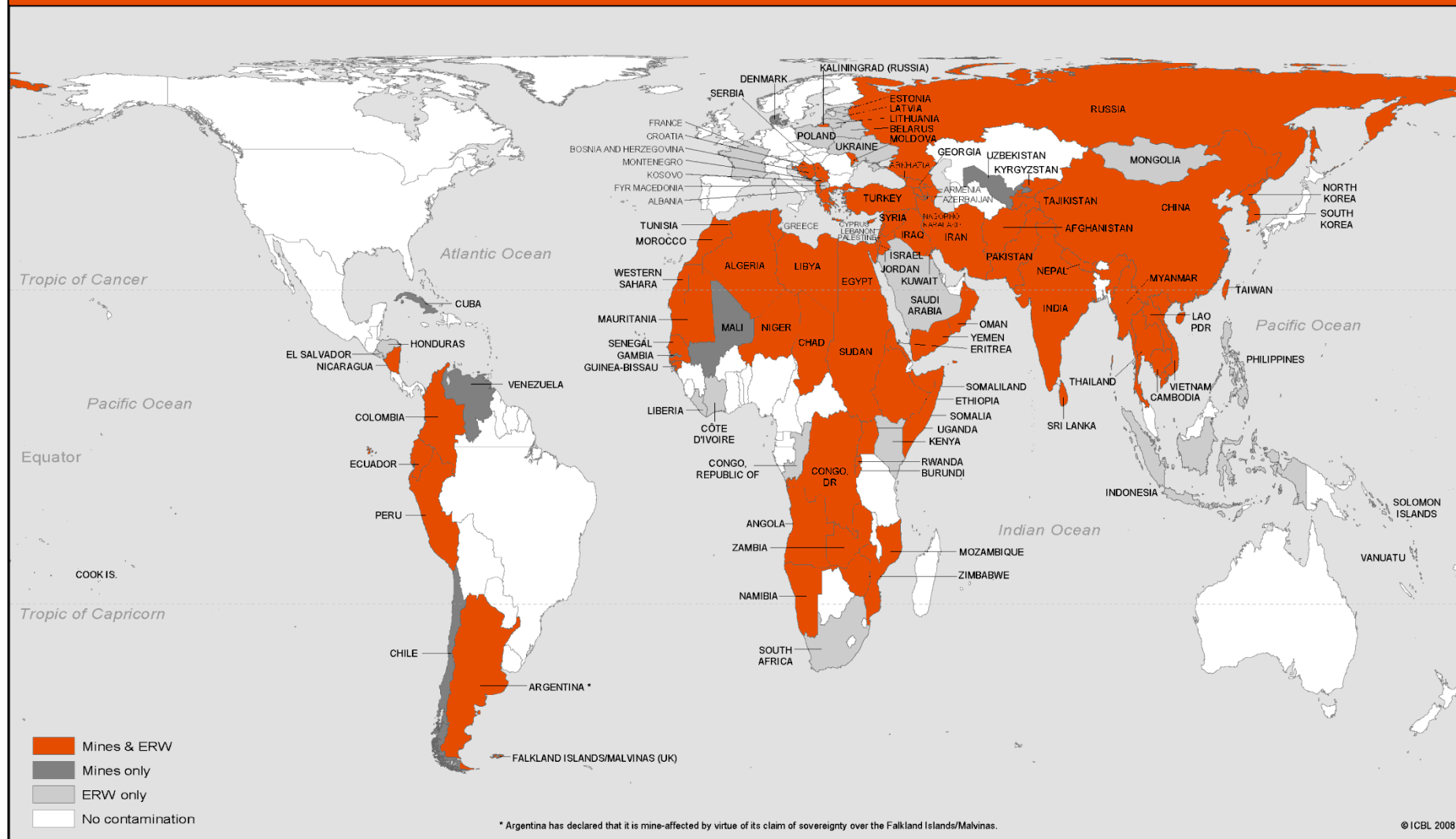
- FY 2009 Department of State (DoS) Humanitarian Demining (HD) Program = **\$12.63M**
- EUCOM AOR FY 2009 DoS HD, Small Arms/Light Weapons Destruction and International Trust Fund = **\$3.350M**





Global Contamination

Global Contamination from Mines and Explosive Remnants of War (ERW)





BALKANS



“Certainly in financial terms, and probably also in land area, this is probably the worst mine problem in the world. Estimates vary, but up to 15,000 square kilometers of land is contaminated with mines and unexploded ordnance. With clearance currently costing between US\$2 and US\$10 per square meter, and about 50 sq kilometers of land cleared in the last 5 years (of which only a small proportion has been fully checked and certified to be safe) progress is awfully slow. Here there is a desperate need for new technologies, even new ways to think about mine clearance. ” (University of Western Australia)



Shaded area represents suspected mine and UXO contamination



Demining in Kosovo



Current Demining efforts are measured in **square meters per day**

Charts show painstakingly slow results of a year long effort



2006 Mine Clearance Results



Operators	Mine/battle area clearance and area reduction (km ²)	APMs destroyed	AVMs destroyed	UXO destroyed
KPC EOD	0.78	97	11	1,483
HALO ^[52]	1.72	51	0	22
MAT	0.23	173	0	69
KFOR ^[53]	N/A	374	73	924
ArmorGroup ^[54]	0.02	0	0	0
Total	2.75	695	84	2,498



A Perspective of Demining in Kosovo 2002-2007



Year	Mined/battle area clearance (m2)
2007	1,080,000
2006	2,754,310
2005	4,310,966
2004	2,730,912
2003	799,242
2002	187,346
Total	11,862,766 = 4.58mi ²

- **138 square miles** suspected to be contaminated in Kosovo (Landmine Monitor Report)
- **4.58 square miles** cleared in the past 6 years
- At 2005 clearing rates it will take ~ **70 years** to complete cleanup
- Meanwhile locals will continue to be killed/injured and not be able to use land for survival/economic development



Current HD methods



Mine Action Assessment

Review of maps, minefield records, questionnaires, interview notes and satellite imagery, types and density of mines and UXO, terrain, weather, local political climate, etc..

Detailed site sketch

- a) Exploratory lanes (if used), and safe access routes as applicable;
- b) Reference Point, Bench Marks, Turning Points and Intermediate Points as applicable;
- c) Distances and bearings from the bench mark and turning points;
- d) Location of visible mines/UXOs and the pattern of mines (if known);
1 This will be based on the suggested clearance depth. The resource estimate will change if the National Mine Action Authority implement a different clearance depth.
- e) Location (s) of any mine, UXOs or other devices destroyed during survey;
- f) Natural prominent features such as hill contours, creeks, bushy areas, etc; and
- g) Other prominent man-made features within the hazardous area (houses, tombs, fortifications, canals, roads, hills, rivers, etc).

Establish search lanes

Spatial lane separation based on threat blast radius

Search lanes manually using hand held metal detectors

Mark suspected mines

Remove or destroy mines in place

Search lanes again to assure clearance probability





Current HD Systems



- Handheld Standoff Mine Detection System (HSTAMIDS)



- Handheld Metal Detectors



- Vehicle Mounted Sensors (MINEDOG)



- Mine Stalker



- Trace Explosive Detectors (FIDO)



- Canines (MINEWOLF)

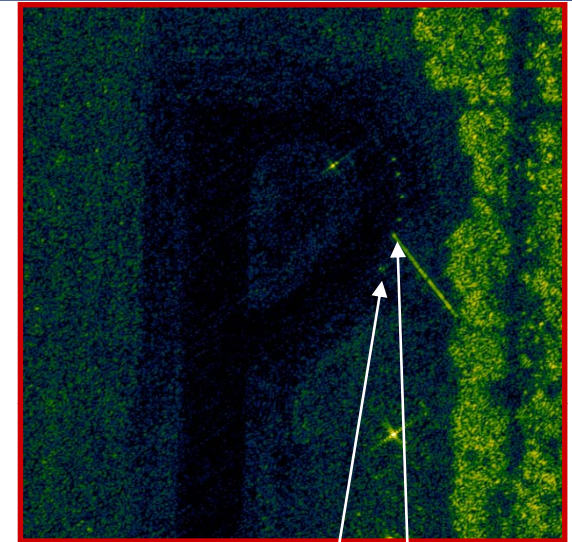




Mine Finder Experiment



- Scope
 - Develop, build, test, and field the worlds most sophisticated Humanitarian Demining and UXO detection system
 - Get people out of the mine field
 - Increase search rate from square meters to square kilometers/day
 - Provide Mine Finder training to candidate countries
 - Leave behind technology/ Information sharing
 - Select three countries of different cultures to measure the effects on the Human Terrain
- Approach
 - Phase I-define/develop/test Mine Finder #1 (MF-1) system, develop baseline metrics for clearance rates and BPC
 - Phase II-Field MF-1 to candidate country, build MF-2 and MF-3
 - Phase III-Field MF2/3 and collect data on detection rates and effect on Human Terrain
 - Phase IV- Analyze results of 3 year test to determine if Mine Finder enables BPC initiatives





Mine Finder Airship



- VHF side and down looking radar
 - Ground penetrating radar, down to ~ 1 meter depending on soil
- Ultra Wideband (UWB) ground penetrating radar
- Profiling Laser Radar (Lidar)
 - Gives height profiles on ground with cm accuracy
- Scanning Laser Radar (Lidar)
 - Scanning optical system with small aperture
 - High resolution precision optical image
- Scanning optical system with small aperture
- High resolution precision optical image
- Coupled Inertial Navigation System (INS) and Two Channel GPS
- Thermal Imaging System
 - Senses and images .01 degree differences in temperature
 - Very useful for precision imaging of metal objects
- Hyperspectral Imaging Camera
 - Optical precision imaging system
 - Looks at differences in sun reflections from different materials
- Sensor and Data Integration and Presentation
- All data is tagged and/or titled with GPS time and location
 - With airborne system navigational accuracy to several meters
 - With a ground based dGPS beacon, accurate to several centimeters





Mine Finder



Experiment Advantages

- Airship is ideally suited for this mission
 - Will be flown in a non threatening environment
 - Normal airship survivability concerns not a factor for this mission
 - Flies safely low and slow
 - Lots of room for apertures
 - Low vibration environment for equipment
 - Can be operated in remote locations (do not need an airport)
 - Need a relatively flat cleared area for operations
 - Need access to AVGAS
 - Can withstand up to 80 knot winds on mooring mast
 - Low fuel burn rate (low carbon footprint)
 - Can act as billboard to communicate messages to locals
 - Considered friendly and non threatening
- Current technology does not allow for real time processing and analysis
- Leave behind technology is a detailed geo-coded map of mine like object locations





Mine Finder Can Address Multiple Mission Areas



- Same Technology can detect
 - Mass Graves
 - Civil Destruction
 - Buried pipelines/tunnels
 - IEDs
- Crisis Consequence Management Assessment and Analysis
 - Disaster management, eg. earthquake, flood, tsunami
 - Track refugee migration



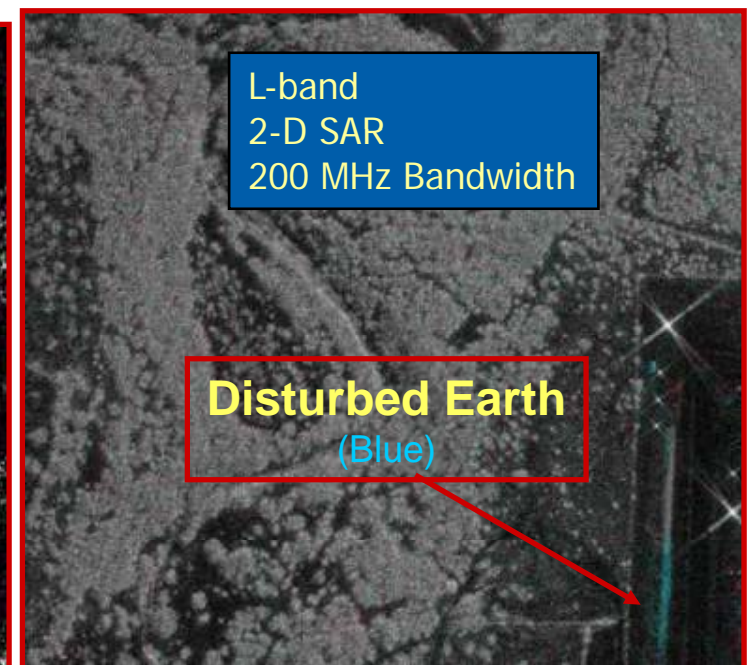
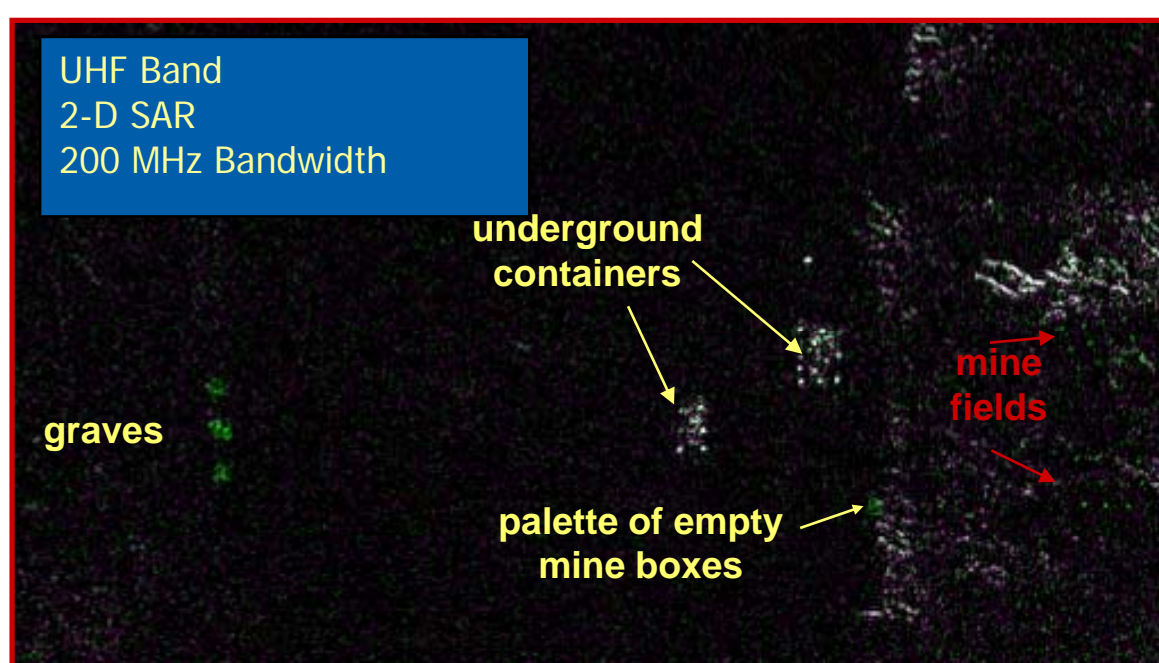


Multi Band Synthetic Aperture Radar (SAR)



Airborne SAR has demonstrated capability to find mine-like objects on surface and buried

Airborne techniques offer safety and speed over traditional HD methods





Conclusions/Recommendations

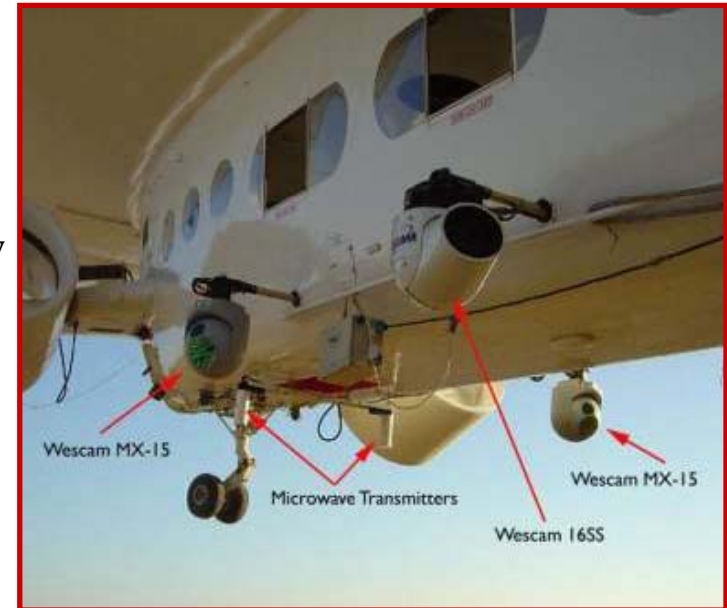


Conclusions:

- Helping countries with the HD problem improves world perception of USA
- Current mine detection techniques are dangerous and slow
- Improving the rate of mine detecting 1000 fold may have a tremendous positive impact
- Airborne mine detection techniques are safer and may be faster then conventional methods
- Airships typically well received and deemed harmless

Recommendations:

- Continue development of Mine Finder proposal
- Identify resources to fund Mine Finder experiment
- Approve and implement the Mine Finder experiment





The End

Questions / Comments?





Mine Finder



Backup Slides



Mine Finder Phase 1



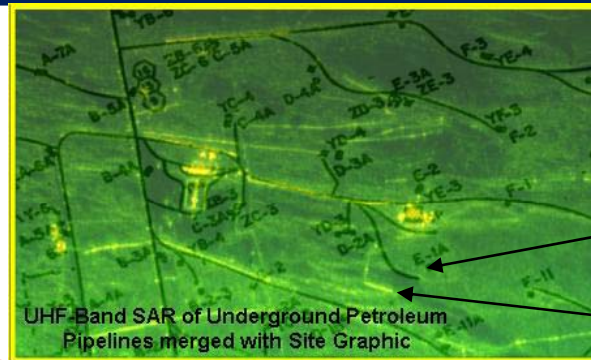
- Design Mine Finder Rader
 - Determine which frequency bands (VHF, UHF, L, S, C, X, K) will provide greatest detection potential for desired target set (buried mines, exposed UXO, ERW) and conditions (buried, foliage, sand)
 - How many different radar bands can the airship hold and experiment afford
 - Determine antenna array element types, number of elements, and spacing that will mount on a commercially available airship
 - Determine processing required for the system
 - Determine ground station capabilities and layout
 - Develop fusion system to merge/overlay data from radars, cameras. maps. satellite information to develop final leave behind product...a high resolution map indicating location of mine like contacts for further investigation/removal
- Identify EO/IR camera system
- Build MF-1
 - Identify funding
 - Award contract (s)
- Test MF-1
 - Construct test plan (inputs from COCOM to make testing relevant)
 - Determine suitable test location
 - Acquire test objects, set up test field, determine probability of detection/false alarm rates
 - Develop algorithms to reduce/eliminate false positives
 - Identify country to receive MF-1 and develop metrics to quantify effects on the human terrain



Mine Finder Phase II/III



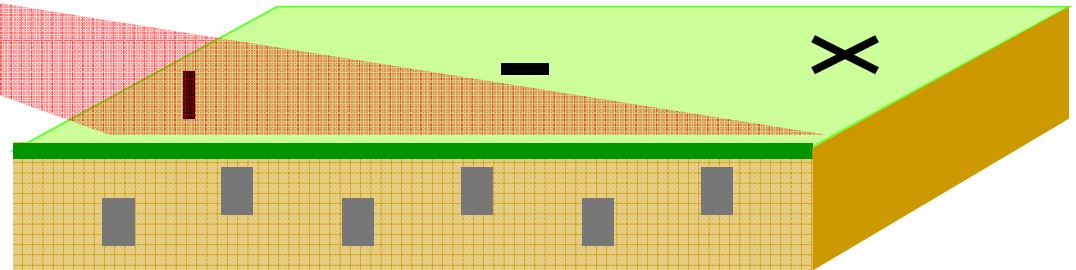
- Phase II
 - Field MF-1
 - Build, test, and field MF-2 and MF-3
 - Identify countries for MF-2 and MF-3 deployment
- Phase III
 - Field MF-2 and MF-3 for a 3 year period
 - Collect data (technical and human terrain)
- Phase IV
 - Analyze results from MF-1,2,and 3
 - Determine overall effect of Mine Finder experiment on human terrain
 - Final report and disposition of Mine Finder systems



Map overlay on SAR imagery of buried pipe shows map errors

—Map location of pipe

— Actual pipe location

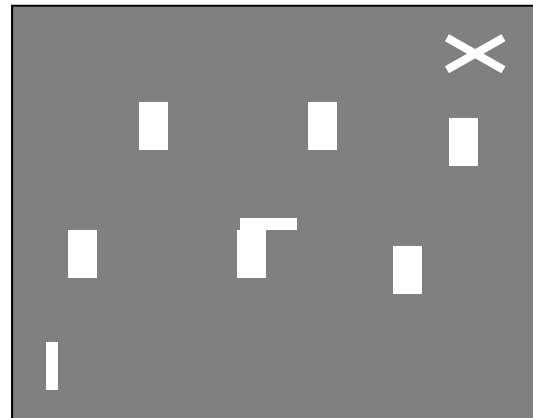


X Band Image



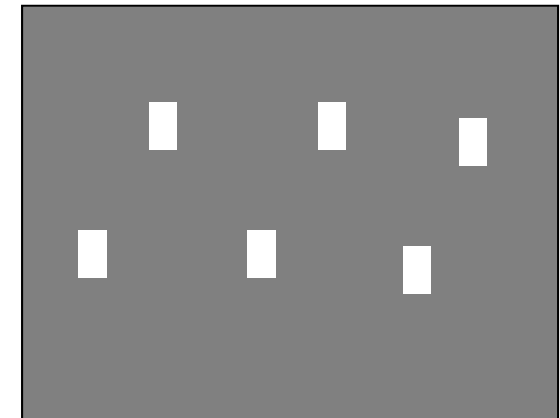
Surface Object Detection

UHF Band Image



Surface & Buried Object Detection

(UHF-X) Image



Buried Object Detection



Summary of SAR Bands



W-Band (MM wavelength): Systems are under development as light-weight radars suitable for small object detection from small aircraft at remote distances to include the classification of specific human targets with the potential to detect concealed weapons. This is the only part of the radar spectrum that has the potential to provide Ground Moving Target Indicators (GMTI) on human target objects. High resolution real-time image products with short duration time-distance apertures are possible with this system technology. W-Band is more sensitive to atmospheric effects than other parts of the SAR spectrum.

Ku-Band (~0.7-inch wavelength): Lightweight Radar systems suitable for small aircraft such as the Fire Scout UAV; excellent for OB object detection and analysis in open terrain; sensitive to some weather and range effects; operational point and shoot targeting systems with real-time image formation processing exist today.

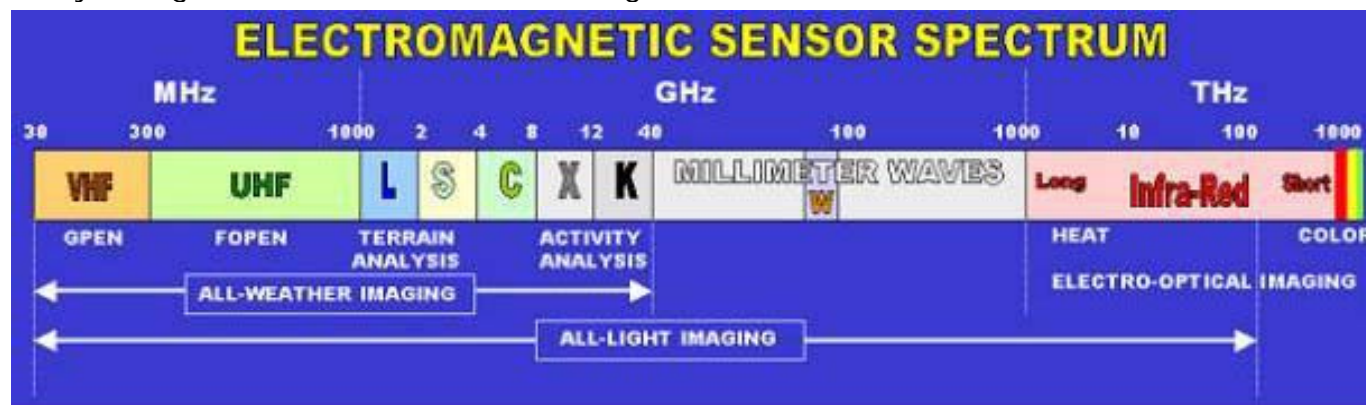
X-Band (~1.2-inch wavelength): Radar systems suitable for medium size aircraft; well suited to OB object detection and analysis in open terrain; less sensitive to weather and range effects than K-Band; operational point and shoot targeting systems with real-time image formation exist today.

C-Band (~2-inch wavelength): Radar systems suitable for medium and large aircraft; well suited to terrain and agricultural crop characterization and analysis. No operational systems exist today.

L-Band (~8-inch wavelength): Radar systems suitable for medium and large aircraft; well suited to terrain, and forest vegetation. This part of the SAR spectrum is generally considered optimal for non-acoustic sea surface effects and characterization.

UHF or P-Band (~24-inch wavelength): Radar systems suitable for large aircraft; best suited to FOPEN and shallow ground penetration (GPEN) applications; requires the development of new processing technologies to make real-time image formation feasible. Current generation aircraft systems require large, ~1-meter cube horn antenna.

VHF-Band (~10-foot wavelength): Radar systems suitable for large aircraft; best suited to GPEN applications; will require the development of new processing technologies to make real-time image formation feasible. Current generation aircraft systems require a large array of Yagi antennas mounted to the wings.

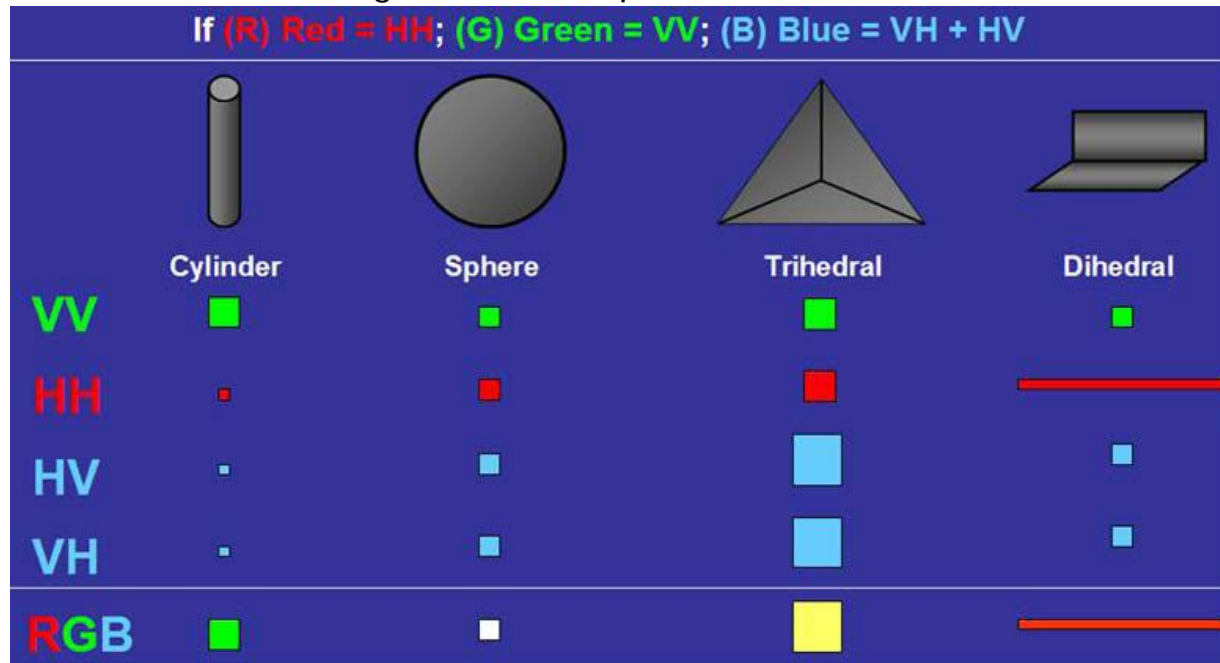




SAR Polarimetry



Why polarimetric SAR? In the first place, polarimetric channels (VV, VH, HH, HV) can be mixed in a variety of red, blue, and green (RGB) color channel combinations that are more pleasing to the human eye than single channel grayscale imagery. Beyond this, the RGB color channels can be interpreted for analysis of reflector shapes that make up target objects throughout a scene. For example, trees are bright in all channels and tend to have the same reflectance in all directions, but manmade objects are dominated by angular shapes that are very sensitive to viewing geometry and polarization. Interpretation techniques and algorithms can be developed to aid in the characterization of terrain, vegetation, and target objects based on a knowledge of the shape and geometry of a target or scene and its related reflectance character in the various polarimetric channels. A study of SAR polarimetry and related EO signatures by use of a hyper-spectral camera could provide powerful new capabilities to detect and identify targets of interest and filter out false positives that may exist by viewing the same targets through narrow pieces of the electromagnetic sensor spectrum.



(U) Humanitarian Mine Finder



Humanitarian Mine Finder

(U) Key Participants

- (U) Sponsor(s): EUCOM
- (U) Gov't Contributors: EUCOM, NAVAIR
- (U) Industry: Airship Management Services, Weeksville, NC; Integrated Systems Solutions, Inc., California, MD;

(U) Key Deliverables:

- (U) Humanitarian Demining Air Platform
- (U) integration design and installation on host Platform
- (U) Training / CONOPS development
- (U) Demonstration and after action report

(U) Technology / Product

- (U) Commercial Lighter Than Air Platform lifting Multi-Band SAR system to altitudes of 5k+ FT MSL
- (U) Fielded Multi-Band SARSystem for integration and host platform
- (U) EUCOM Humanitarian Demining
- (U) Development, Testing, Integration & Certification

(U) The So What

- (U) Provides unexploded ordinance detection, location, and identification for disposal
- (U) Provides indication of where mines are not located or found

Source	Prior FY08	FY08	FY09	Total
RRT0				
USSOCOM				
OGA				
TOTAL				

¹ Significant comment about cost /past investment etc.

(U) Milestones Leading to Fielded Capability

- (U) Contract for Test article 1 June 09
- (U) Modification, delivery, install 15 August 09
- (U) Combined DT/OT 30 July 09
- (U) Procurement Decision TBD
- (U) Deployment TBD

(U) Sponsor:

(U) PM PoC: Steve Huett; stephen.huett@navy.mil ; 301-757-3009

(U) Technical POC:



Mine Finder Graphics

